International Journal of Mechanical and Production Engineering Research and Development (IJMPERD)
ISSN (P): 2249-6890; ISSN (E): 2249-8001
Vol. 7, Issue 3, Jun 2017, 7-16

EVALUATION OF MACHINABILITY OF D2 STEEL USING CRYO TREATED CERMET USING TAGUCHI TECHNIQUE

S. KRISHNAKUMAR[1] P. VIJAYAKUMAR[2] & R. MAKESHKUMAR[3]

[1]*PG Scholar, Department of Mechanical Engineering, Prist University, Thanjavur, Tamil Nadu, India*

[2 3]*Assistant Professor, Department of Mechanical Engineering, Prist University, Thanjavur, Tamil Nadu India*

ABSTRACT

Machining of materials by super hard instrument like PCBN is to diminish apparatus wear to got dimensional precision, smooth surface and more number of parts per bleeding edge. Wear of instruments inescapable because of rubbing activity between work material and device edge. Be that as it may, the instrument wear can be limited by utilizing super hard devices by upgrading the quality of the cutting supplements. Broad review has been directed in the past to enhance the procedure parameters in any machining procedure to have the best item. Current examination on turning procedure is a Taguchi enhancement method connected on the best procedure parameters i.e. nourish, cutting pace and profundity of cut while machining the D2 with Cryo treated CERMET apparatus. The examinations were done by a CNC machine, utilizing cryo treated cermet apparatus for the machining of D2 steel. The Taguchi method and ANOVA were utilized to acquire ideal Turning parameters in the Turning of D2 under wet conditions. The ideal control figure for Surface Roughness-were Speed is 2000, Feed – 0.04 DOC 0.25, and Machining Timing were Speed 1750, Feed 0.02, DOC 0.75 and Material Removal Rate Speed 1750, Feed 0.02, DOC 0.75. The Percentage of commitment for each Process parameter are Surface Roughness DOC was 49%, Machining Timing food was 93%, Material Removal Rate FEED was 44%.

KEYWORDS: Smooth Surface, Device Edge, Nourish & Cutting Pace

Received: Mar 06, 2017; **Accepted**: Mar 24, 2017; **Published**: Apr 21, 2017; **Paper Id**.: IJMPERDJUN20172

INTRODUCTION

Machining

The test of present day machining enterprises is chiefly centered around the accomplishment of high caliber regarding surface complete, high creation industry, work rate, economy of machining as far as cost sparing and increment the execution of the item with diminished natural effect. Machining of solidified steel is especially basic in bearing and car ventures.

The new accomplishment in machine apparatuses innovation and utilization of new slicing instruments give the chance to take loads from solidified steel through process, for example, lathing.

HARD TURNING OPERATION

Hard turning is considered as another machining procedure went for turning solidified steel with high metal expulsion rate, great surface complete and in addition less instrument wear. Hard turning is a decent option for some granulating application which were beforehand done through conventional machining process. Ordinarily the hard turning operation is performed on materials having hardness values more than 45 HRC in "C" size of

Original Article

hardness analyzer. Hard swinging used to turn solidified steel which is utilized for vehicle ventures and bearing businesses. Hard turning is the most recent pattern in all assembling ventures and it is a beneficial contrasting option to crushing.

CNC TURNING MACHINE

The CNC turning is a machine tool capable of performing various turning and related operations, on work piece in one set up under CNC system. These are generally provided with two axis control, Z axis parallel to the spindle and X axis perpendicular to the spindle axis. Turning centres are provided with a slant bed to allow for better view of the machining plane as well as for easy placement of various devices involved in the machine zone. It also provided various types.

LITERATURE REVIEW

Sujan Debnath, Moola Mohan Reddy, Qua Sok Yi [1]: Were experimentally carried out the effect of various cutting fluid levels and cutting parameters on surface roughness and tool wear was studied. Taguchi orthogonal exhibit was utilized to limit the quantity of analyses. The tests were done on mellow steel bar utilizing a TiCN + Al2O3 + TiN covered carbide instrument embed in the CNC turning process. The impact of bolster rate was observed to be the predominant component contributing 34.3% to surface unpleasantness of the work-piece. The stream rate of the cutting liquid likewise demonstrated a noteworthy commitment (33.1%). In any case, cutting velocity and profundity of slice indicated little commitment to surface unpleasantness. Then again, cutting rate (43.1%) and profundity of cut (35.8%) were the predominant elements affecting apparatus wear. Be that as it may, utilization of cutting liquid (13.7%) demonstrated an impressive commitment, while the nourish rate gave minimal commitment to apparatus wear. The ideal cutting conditions for craved surface unpleasantness and apparatus wear were at an abnormal state of cutting pace, medium level of profundity of cut, low level of sustain rate and low flow high-velocity (LFHV) cutting liquid spill out of the chose levels.

V. Kryzhanivskyy, V.Bushlya, O.Gutnichenko, I.A.Petrusha, J.E.Stahl [3]: Were concentrated the cutting apparatus temperature that creates amid harsh turning of solidified cool work device steel is displayed on the premise of trial information. The information acquired from a progression of thermocouples, put on a PCBN embed, into an iron block, and into a device holder, were utilized as the contribution for the model. An opposite issue was settled, where the warmth fluxes and warm exchange coefficients were figured and where the created temperature field was remade from the test readings. The temperature was displayed for the instance of new instruments, and in addition for the instance of its improvement over the span of hardware wear. The machining case included usage of a high-CBN content and a fastener less PCBN review, both having high warm conductivity of 110 and 190 W/m K individually.

Wojciech Zębala, Robert Kowalczyk, Andrzej Matras [4]: Were exhibited the aftereffects of the cutting powers examine (Ff, Fp, Fc) when machining of sintered carbides WC-Co (25 % Co) with instruments made of polycrystalline jewel PCD. Embeds with three diverse nose radii $r\varepsilon$ were utilized amid the review. Each removing test was carried on the separation 54 mm at the consistent profundity of cut 0.2 mm. The greatest increment of inactive cutting power part Fp was demonstrated. Furthermore, the scientific models for cutting power esteem expectation as the cutting way increments are exhibited. The paper exhibits additionally the calculation of streamlining and control of the super hard materials turning process.

Jinming Zhou, Volodymyr Bushilya, Ru Lin Peng, Zhe Chen, Sten Johansson, Jan Eric Stahl [5]: Were analyzed subsurface miniaturized scale auxiliary changes and leftover anxieties created by machining altogether influence part lifetime and execution by impacting exhaustion, crawl, and stress consumption splitting resistance. Evaluating the

surface nature of a machined part by describing subsurface miniaturized scale auxiliary modifications and lingering stresses is basic for guaranteeing part execution and lifetime in air motors and power generators. This relative review portrays and breaks down subsurface smaller scale auxiliary changes and leftover worries in Inconel 718 subjected to rapid machining with PCBN and bristle strengthened earthenware cutting devices. Impacts of cutting apparatus materials and miniaturized scale geometry on subsurface misshapening, small scale auxiliary adjustments, and leftover burdens were explored. Surface and subsurface districts of machined examples were explored utilizing X-beam diffraction, electron diverting difference imaging, and electron back-scramble diffraction to portray smaller scale auxiliary changes and measure distortion force and profundity.

Scope of the Project

To analyse the effect process parameters the cutting speed, feed and depth of cut in machining process, hard turning of D2 steel and formulate a mathematical model for responses metal removal rate, machining time and surface roughness to find optimal values of cutting parameters of the CRYO treated CERMET inserts

SELECTION OF OBJECTIVE FUNCTION

The above literature review has shown that less effort has been contribute for metal removal rate, machining time and surface roughness in CNC turning operation on D2steel. Thus machining time, metal removal rate and surface roughness while machining of CRYO cermet inserts has been chosen as objective function.

CRYOGENIC PROCESS -INTRODUCTION

Tools wears constantly, when are being used in manufacturing, cutting and forming processes, reducing tool wear is important in various manufacturing processes in order to increase tool life for reducing the cost of production. The efficiency of the tool depends upon the time for which it is used for removing of material, as the wear of the cutting edge gradually increases, the precision and the quality of the surface finish of the work piece decreases, the tools have to withstand high temperature and stress during cutting, and have to absorb cutting forces produced during machining. Also tool material must be corrosion resistant and chemically inert towards the work piece material. The primary objective of the heat treatment of die/tool steels is to impart high wear and abrasive resistance, but one of the major problems in the conventional heat treatment through hardening and tempering of these steels is the content of retained austenite, which is soft, unstable at low temperature and transforms into brittle marten site during service. Transformation of austenite to marten site is associated with approximately 4.3 % volume expansion, which causes distortion of the components. Thus sub-zero treatment or cryogenic is used for minimizing the amount of retained austenite content in tool steels. Cryogenic processing had its US origins in the 1940s. Cryogenic processing will make the metal harder &therefore more brittle, Cryogenic processing has no effect on low carbon steel, cast iron and non ferrous metal. Cryogenic preparing rolls out improvements to the structure of the materials being dealt with and subject to the creation of the material, it performs three things; held austenite swung to martensite, carbide structures are refined and stress is assuaged. Cryogenic handling won't in itself solidify metal like extinguishing and hardening, it is an extra treatment to warm treating. The advantages of this procedure incorporates; lessening of grating and glue wear, enhanced machining properties coming about because of the lasting change of the structure of the metal, decrease of the recurrence and cost of hardware remanufacturing and diminishment of calamitous apparatus disappointment because of stress crack. A particular rate of held austenite might be coveted for applications, for example, heading or apparatuses where the metal may require some sturdiness to ingest effect or torsion stacking.

Cryotreatment

At fluid nitrogen temperatures makes conditions for the resulting nucleation of fine carbides in high composite steels. Cryogenics is a generally new process used to take out held austenite; in which the temperature must be brought down. In cryogenic treatment the material is to be profound stop temperatures of as low as 90 K. A cryogenic processor is utilized to achieve ultra-low temperatures of around 125 K. The cooling is performed at ease back rate to anticipate warm stun to the segments being dealt with. The principal business unit was created by in the late 1960s. The advancement of programmable microchip controls permits the machines to take after temperature profiles that extraordinarily expanded the viability of the procedure. Before programmable controls were added to control cryogenic processors, the "treatment" procedure of a protest was done physically by drenching the question in fluid nitrogen. This regularly made warm stun happen inside a protest, bringing about breaks to the structure. Current cryogenic processors measure changes in temperature and modify the contribution of fluid nitrogen in like manner to guarantee that lone little fragmentary changes in temperature happen over a drawn out stretch of time. Cryogenic processors arrive in an assortment of sizes and arrangements. The processors are regularly intended to suit group or ceaseless loads and come in two styles, front stacking and beat stacking. The fitting outline relies on the generation volume and part design of a plant.

Definition of Cryogenic

In physical science, cryogenics is the investigation of the generation of low temperature (underneath −150 ° C, −238 °F or 123 K) and the conduct of materials at those temperatures. As opposed to the recognizable temperature sizes of Fahrenheit and Celsius, cryogenicists utilize the Kelvin (and once in the past Rankine) scales. A man who ponders components under to a great degree cool temperature is known as a cryogenicist. It is gotten from the Greek word as, Cryo – Cooling, Genic - Generation.

Cryogenic Solution

The diverse sorts of cryogenic arrangements utilized for the treatment of fast Steels. They are,

- Liquid Nitrogen (- 196°c),
- Liquid Helium (- 297°c)

Liquid Helium

Fluid nitrogen is a cryogenic fluid. At barometrical weight, it bubbles at −195.8 °C. At the point when protected in legitimate holders, for example, Dewar cups, it can be transported without much evaporative misfortune. Like dry ice, the principle utilization of fluid nitrogen is as a refrigerant. In addition to other things, it is utilized as a part of the cryopreservation of blood, regenerative cells (sperm and egg), and other natural examples and materials. It is utilized as a part of icy traps for certain lab gear and to cool x-beam finders. It has likewise been utilized to cool focal preparing units and different gadgets in PCs which are over timed, and which deliver more warmth than amid typical operation.

Properties of Liquid Nitrogen

- Density - 1.251 g/L,
- Melting point - 63.153K(210°c),
- Boiling point - 77.36K (- 195.79°c)

- Critical point - 126.19K,
- Heat of vaporization - 5.56KJ/mol

In these two sorts of cryogenic arrangements, we are chosen to do our venture in Liquid

Nitrogen. Since it can be get from Veterinary clinic and effectively accessible than fluid helium. The fluid nitrogen is utilized as an additive to protect the semen circulating infusion in it

Design of Experiment

Process parameters and their levels responses for all noise factors for the given factor level combination

Table 1

Levels	Process Parameters		
	Spindle Speed (*N*) (rpm)	Feed (*f*) (mm/rev)	Depth of Cut
1	1500	0.02	0.25
2	1750	0.04	0.50
3	2000	0.06	0.75

Minitab-16 Software By using Minitab-16 software have optimized the drilling parameters.

WORK PIECE MATERIAL

Work material –D2steel

Work material size–32mm dia. 60 mm Length

D2 steel is an air solidifying, high-carbon, high-chromium apparatus steel. It has high wear and scraped spot safe properties. It is warmth treatable and will offer a hardness in the range 55-62 HRC, and is machinable in the tempered condition. D2 steel indicates little contortion on right solidifying. D2 steel's high chromium content gives it mellow consumption opposing properties in the solidified condition. Chilly work instrument steels incorporate the high-carbon, high-chromium steels or gathering D steels. These steels are assigned as gathering D steels and comprise of D2, D3, D4, D5, and D7 steels. These steels contain 1.5 to 2.35% of carbon and 12% of chromium. But sort D3 steel, the various gathering D steels incorporate 1% Mo and are air solidified. Sort D3 steel is oil-extinguished; however little areas can be gas extinguished after austenitization utilizing vacuum. Therefore, instruments made with sort D3 steel has a tendency to be fragile amid solidifying. Sort D2 steel is the most normally utilized steel among the gathering D steels.

Cutting Tool Material

A cermet is a composite material made out of ceramic (cer) and metallic (met) materials.

A cermet is in a perfect world intended to have the ideal properties of both an artistic, for example, high temperature resistance and hardness, and those of a metal, for example, the capacity to experience plastic disfigurement. The metal is utilized as a cover for an oxide, boride, or carbide. For the most part, the metallic components utilized are nickel, molybdenum, and cobalt. Contingent upon the physical structure of the material, cermets can likewise be metal network composites, however cermets are generally under 20% metal by volume. Cermets are utilized as a part of the fabricate of resistors (particularly potentiometers), capacitors, and other electronic segments which may encounter high temperature.

Cermets are utilized rather than tungsten carbide in saws and other brazed devices because of their unrivaled wear and consumption properties. Titanium nitride (TiN), titanium carbonitride (TiCN), titanium carbide (TiC) and comparable can be brazed like tungsten carbide if appropriately arranged anyway they require uncommon dealing with amid granulating.

More mind boggling materials, known as Cermet 2 or Cermet II, are being used on the grounds that they empower significantly longer life in cutting instruments, while as yet brazing and crushing like tungsten carbide.

A few sorts of cermets are likewise being considered for use as shuttle protecting as they oppose the high speed effects of micrometeoroids and orbital debrismuch more viably than more conventional rocket materials, for example, aluminum and different metals.

Tipped Inserts

- Require a transporter and substrate for the embed.
- The tips are brazed to the substrate. Different brazing techniques are connected.
- The substrate needs to have a pocket that will suit and bolster the tip.
- • In these sorts of apparatuses, the braze joint speaks to the feeble connection, so the brazing operation is essential and ought to be deliberately controlled and executed.
- The principle favorable position of tipped devices over full-confronted supplements is the lower cost.

Figure 1

Experimental Arrangement and Process Parameters Levels

- **Machine Tool:** LMW smarturn CNC lathe.
- **Work Specimen Material:** EN 353.
- **Size of Material:** Φ32mm X 75 mm.
- **Tool Material:** PCBN inserts.
- **Environment:** Coolant used.
- **Metal Removal Rate Calculation:** Through weight.
- **Machining Time Measurement:** From CNC machine.

Figure 2

EXPERIMENTAL DATA WITH OPTIMIZATION

Experimental Data

Table 2

Trial No.	Designation	Speed	Feed	Doc	Machining Time Sec	Ra Micron	Mrr Gm/Sec
1	$A_1B_1C_1$	1500	0.02	0.25	107	0.848	0.025
2	$A_1B_2C_2$	1500	0.04	0.50	56	0.774	0.066
3	$A_1B_3C_3$	1500	0.06	0.75	39	0.484	0.092
4	$A_2B_1C_2$	1750	0.02	0.50	93	0.867	0.038
5	$A_2B_2C_3$	1750	0.04	0.75	49	0.614	0.052
6	$A_2B_3C_1$	1750	0.06	0.25	35	0.615	0.080
7	$A_3B_1C_3$	2000	0.02	0.75	83	0.612	0.031
8	$A_3B_2C_1$	2000	0.04	0.25	44	1.102	0.031
9	$A_3B_3C_2$	2000	0.06	0.50	31	0.751	0.033

MACHINING TIME (ANALYSIS OF RESULT)

Machining Time and S/N Ratios Values for the Experiments

Table 3

Trial No.	Designation	Speed	Feed	Doc	Machining Time	Snra1
1	$A_1B_1C_1$	1500	0.02	0.25	107	-40.5877
2	$A_1B_2C_2$	1500	0.04	0.50	56	-34.9638
3	$A_1B_3C_3$	1500	0.06	0.75	39	-31.8213
4	$A_2B_1C_2$	1750	0.02	0.50	93	-39.3697
5	$A_2B_2C_3$	1750	0.04	0.75	49	-33.8039
6	$A_2B_3C_1$	1750	0.06	0.25	35	-30.8814
7	$A_3B_1C_3$	2000	0.02	0.75	83	-38.3816
8	$A_3B_2C_1$	2000	0.04	0.25	44	-32.8691
9	$A_3B_3C_2$	2000	0.06	0.50	31	-29.8272

MACHINING TIME FOR EACH LEVEL OF THE PROCESS PARAMETER

Response Table for Signal to Noise Ratios

Smaller is better

Table 4

Level	Speed	Feed	DOC
1	-35.79	-39.45	-34.78
2	-34.68	-33.88	-34.72
3	-33.69	-30.84	-34.67
Delta	2.10	8.60	0.11
Rank	**2**	**1**	**3**

ANALYSIS OF VARIANCE (ANOVA)

Analysis of Variance (ANOVA) results for the MACHINING TIME

Table 5

Source	DF	SS	MS	F	P	% of Contribution
Speed	2	324.67	162.33	9.94	0.091	5
Feed	2	5730.67	2865.33	175.43	0.006	93
DOC	2	38.00	19.00	1.16	0.462	1
Error	2	32.67	16.33			1
Total	**8**	**6126.00**				**100**

SURFACE ROUGHNESSES (ANALYSIS OF RESULT)

Surface Roughness and S/N Ratios Values for the Experiments

Table 6

Trial No.	Designation	Speed	Feed	Doc	Ra	Snra1
1	$A_1B_1C_1$	1500	0.02	0.25	0.848	1.43208
2	$A_1B_2C_2$	1500	0.04	0.50	0.774	2.22518
3	$A_1B_3C_3$	1500	0.06	0.75	0.484	6.30309
4	$A_2B_1C_2$	1750	0.02	0.50	0.867	1.23962
5	$A_2B_2C_3$	1750	0.04	0.75	0.614	4.23663
6	$A_2B_3C_1$	1750	0.06	0.25	0.615	4.22250
7	$A_3B_1C_3$	2000	0.02	0.75	0.612	4.26497
8	$A_3B_2C_1$	2000	0.04	0.25	1.102	-0.84363
9	$A_3B_3C_2$	2000	0.06	0.50	0.751	2.48720

Roughness Response for Each Level of the Process Parameter

Response Table for Signal to Noise Ratios Smaller is better

Table 7

Level	Speed	Feed	DOC
1	3.320	2.312	1.604
2	3.233	1.873	1.984
3	1.970	4.338	4.935
Delta	1.351	2.465	3.331
Rank	**3**	**2**	**1**

Analysis of Variance (ANOVA)

Analysis of Variance (ANOVA) results for the Roughness

Table 8

Source	DF	SS	MS	F	P	% of Contribution
Speed	2	0.02946	0.01473	0.86	0.536	11
Feed	2	0.07374	0.03687	2.16	0.316	27
DOC	2	0.13623	0.06812	4.00	0.200	49
Error	2	0.03409	0.01705			13
Total	**8**	**0.27353**				**100**

MRR (Analysis of Result)

MRR And S/N Ratios Values for the Experiments

Table 9

Trial No.	Designation	Speed	Feed	Doc	Mrr	Snra1
1	$A_1B_1C_1$	1500	0.02	0.25	0.025	-32.0412
2	$A_1B_2C_2$	1500	0.04	0.50	0.066	-23.6091
3	$A_1B_3C_3$	1500	0.06	0.75	0.092	-20.7242
4	$A_2B_1C_2$	1750	0.02	0.50	0.038	-28.4043
5	$A_2B_2C_3$	1750	0.04	0.75	0.052	-25.6799
6	$A_2B_3C_1$	1750	0.06	0.25	0.080	-21.9382
7	$A_3B_1C_3$	2000	0.02	0.75	0.031	-30.1728
8	$A_3B_2C_1$	2000	0.04	0.25	0.031	-30.1728
9	$A_3B_3C_2$	2000	0.06	0.50	0.033	-29.6297

Machining Time for Each Level of the Process Parameter

Response Table for Signal to Noise Ratios Smaller is better

Table 10

Level	Speed	Feed	DOC
1	-25.16	-30.21	-28.05
2	-25.34	-26.49	-27.21
3	-29.99	-24.10	-25.53
Delta	4.65	6.11	2.53
Rank	**2**	**1**	**3**

Analysis of Variance (ANOVA)

Analysis of Variance (ANOVA) results for the MACHINING TIME

Table 11

Source	DF	SS	MS	F	P	% of Contribution
Speed	2	0.001504	0.000752	1.84	0.352	31
Feed	2	0.002054	0.001027	2.52	0.284	44
DOC	2	0.000330	0.000165	0.40	0.712	8
Error	2	0.000816	0.000408			17
Total	**8**	**0.004704**				**100**

CONCLUSIONS

In this study, the Taugchi technique and ANOVA were used to obtain optimal Turning parameters in the Turning of D2 under wet conditions. The experimental results were evaluated using Taguchi technique. The following conclusion can be drawn.

OPTIMAL CONTROL FACTOR

- Surface Roughness-A3(Speed - 2000)B2(Feed – 0.04)C1(DOC – 0.25)
- Machining Timing-A2(Speed-1750)B1(Feed 0.02)C3(DOC 075)
- Material Removal Rate- A2(Speed-1750)B1(Feed 0.02)C3(DOC 0.75)

Percentage of Contribution of Process Parameter

Surface Roughness- DOC 492. Machining Timing-Feed-.93%3. Material Removal Rate.

REFERENCES

1. *SujanDebnath, Moola Mohan Reddy, Qua Sok Yi " Influence of cutting fluid conditions and cutting parameters on surface roughness and tool wear in turning process using Taguchi method" Received in revised form 11 September 2015, Accepted 15 September 2015, Available online 26 September 2015.*
2. *R. K. Bharilya, RiteshMalgaya, LakhanPatidar, R. K. Gurjar, Dr. A. K. Jha "Study of optimized process parameters in turning operation through Force Dynamometer on CNC Machine" Materials Today: Proceedings 2 (2015) 2300 – 2305.*
3. *V. Kryzhanivskyy, V. Bushlya, O. Gutnichenko, I. A. Petrusha, J. -E. Ståhl "Modelling and Experimental Investigation of Cutting Temperature when Rough Turning Hardened Tool Steel with PCBN Tools" Procedia CIRP 31 (2015) 489 – 495.*
4. *WojciechZębala, Robert Kowalczyk, AndrzejMatras "Analysis and Optimization of Sintered Carbides Turning with PCDTools" Procedia Engineering 100 (2015) 283 – 290.*
5. *Jinming Zhou, VolodymyrBushlya, Ru Lin Peng, Zhe Chen, Sten Johansson and Jan Eric Stahl "Analysis of subsurface microstructure and residual stresses inmachined Inconel 718 with PCBN and Al2O3-SiCw tools" Procedia CIRP 13 (2014) 150 – 155.*
6. *RachidM'Saoubi, Tobias Czotscher, OlofAndersson, Daniel Meyer "Machinability of powder metallurgy steels using PcBN inserts" Procedia CIRP 14 (2014) 83 – 88.*
7. *DiptiKanta Das, Ashok Kumar Sahoo, Ratnakar Das, B. C. Routara "Investigations on hard turning using coated carbide insert: Greybased Taguchi and regression methodology" Procedia Materials Science 6 (2014) 1351 – 1358.*